

## DEVELOPING APPARATUS

### FIELD OF THE INVENTION AND RELATED ART:

The present invention relates to a developing  
5 device for developing an electrostatic latent image  
formed on an image bearing member, more particularly  
to a developing apparatus usable with a copying  
machine, a printer, a facsimile machine or the like.

Conventional image forming apparatus of this  
10 kind includes a copying machine, a printer and so on.  
Referring first to Figure 17, a conventional image  
forming apparatus and an image forming process will be  
prescribed. Figure 17 is a schematic illustration of  
an image formation process portion of a conventional  
15 image forming apparatus.

An image bearing member in the form of an  
electrophotographic photosensitive member (rotatable  
drum) 50 is rotated in the direction indicated by an  
arrow X, and is uniformly charged by charging means  
20 54. The surface of the photosensitive drum 50 is  
exposed to image light 55 so that latent image is  
formed thereon. Using a developing device 56, a  
developer (toner) is electrostatically deposited onto  
the electrostatic latent image by which the latent  
25 image on the photosensitive drum 50 is developed into  
a toner image.

Thereafter, the toner image is transferred

onto a recording material (sheet) fed in synchronism with the toner image formation, by a transferring means in the form of a transfer charger 52 which is supplied with a bias voltage having a polarity opposed to that of the toner.

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100-330-44-444  
The transferring means and may be a contact type transferring means represented by a transfer roller in place of the transfer charger 52. The contact transferring means is advantageous in that amount of production of electric discharge product such as ozone is smaller as compared with the charger.

As for the developing system, there are a regular developing system in which the background portion of the image information on the surface of the photosensitive drum 50 uniformly charged, is exposed to light, and the toner is deposited to the portion other than the exposed portion; and a reverse development type in which the portion of surface of the photosensitive drum 50 corresponding to the image information is exposed to light, and the toner is deposited on the exposed portion.

In such a conventional image forming apparatus, there there are provided guiding members (upper guiding member 53a which is a first guiding member and lower guiding member 53b which is a second guiding member) for guiding the upper surface and the lower surface of the recording material 51 so as to

assuredly introduce the recording material 51 to the transfer station where the toner image is transferred onto the recording material.

5 Adjacent the upper guiding member 53a and the lower guiding member 53b, the image transfer bias voltage is applied by the transfer charger 52. Therefore, if the recording material 51 becomes wet under a high humidity ambience condition with results of decrease of the existence, there is a possibility  
10 that image transfer bias voltage leaks to the upper guiding member 53a and the lower guiding member 53b through the recording material 51. In order to avoid such a problem, the upper guiding member 53a and the lower guiding member 53b are made of insulating  
15 members.

In this manner, partial void of image transfer due to insufficient electric charge, or the like problem are avoided.

20 However, since the upper guiding member 53a and the lower guiding member 53b are made of the insulating members, they tended to be electrically charged to the same polarity as the image transfer bias voltage applied to the adjacent transfer charger 52, that is, the polarity opposite from that of the  
25 toner.

The upper guiding member 53a and the lower guiding member 53b are disposed close to the transfer

charger 52, and therefore, are also close to the photosensitive drum 50 in order to assuredly introduce the recording material 51 to the image transfer station, more particularly, they are as close as approx. 1-3mm from the surface of the photosensitive drum 50.

Accordingly, they are easily charged to the polarity opposite from that of the toner. In addition, the toner floating within the apparatus, particularly the toner of the toner image on the surface of the photosensitive drum 50 at the position immediately before the image transfer position, are electrostatically attracted and deposited on the upper guiding member 53a and the lower guiding member 53b.

15 The tendency of the toner deposition is strongest at the leading end portion 53S of the upper guide 53a, which portions is closest to the surface of the photosensitive drum 50. As a result, there arises a liability that contamination toner is deposited onto  
20 the recording material 51, which leads to deterioration of the image quality.

In a type which is represented by the reverse development type, in which the toner image is deposited on the portions at which the potential has attenuated due to exposure, the depositing force of the toner to the photosensitive drum 50 is relatively weak, and the tendency of the toner being attracted to

the upper guiding member 53a is stronger.

In addition, the toner particles which has scattered may be deposited on the lower guiding member 53b.

5           It is known that in order to solve such a problem, the upper guiding member 53a and the lower guiding member 53b are made of electroconductive members which are supplied with a bias voltage having a polarity opposite to that of the image transfer bias  
10 voltage (the same polarity as the toner) to prevent the toner deposition thereon.

          In such a case, there occurs a tendency that image transfer bias voltage (the opposite polarity from the toner) to leak, and therefore, the transfer  
15 void is relatively remarkable due to the shortage of the charge to be retained by the recording material 51 or due to the decrease of the resistance due to the moisture absorption of the recording material 51. To avoid this problem, the inner surfaces of the upper  
20 and lower guides which are contactable to the recording material 51 is coated with insulation sheets so as to prevent the leakage of the transferring current.

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25           However, such a prior-art structure involves the following problems.

          As described in the foregoing, by applying the voltage of the same polarity as the toner to the

guiding member, the toner scattered from the toner carrying member (developing sleeve) provided in the developing device and/or the regular-charge toner (the toner having the regular polarity charge) in the developed image on the photosensitive drum, are prevented from depositing.

However, under the low humidity ambient condition, particularly when the toner particularly property is deteriorated due to the long term operation of the developing device, the amount of the toner having the charge of polarity opposite from the polarity of the charge of the regular toner.

The toner having the opposite polarity charge is called reversely charged toner, which produces background fog or shadowing which is unintended deposition of the toner around a line letter.

Since the reversely charged toner has the same polarity as the transferring potential, it is not easily transferred onto the recording material 51.

However, as described in the foregoing, since the potential applied to the dining members (having the same polarity as the regular toner) and the reversely charged toner, have the opposite polarities, the reversely charged toner are relatively easily deposited on the guiding members. The contamination toner deposited on the guiding members, are deposited in turn onto the recording material 51 with the result

of contamination and/or image quality deterioration.

5 In addition, when the developing device is  
operated with a low print ratio under an extremely low  
humidity condition such as 23°C, 5% in durability  
test, the deterioration of the toner is promoted even  
to such an extent that amount of the reversely charged  
toner increases, and the reversely charged toner  
deposited on the free end of the upper guide from the  
photosensitive drum, during the post-rotation; the  
10 contamination occurs at the leading and trailing edges  
of the recording material at each of the image forming  
operations. The problem is not only with the transfer  
guide, but a member disposed too close to the drum is  
contaminated due to the air flow caused by rotation of  
15 the drum. The increase of the amount of the reversely  
charged toner results in increased amount of the  
untransferred toner. The toner on a toner receptor  
sheet disposed upstream of the cleaning blade may fall  
therefrom onto the recording sheet, thus again  
20 contaminate the recording material.

#### SUMMARY OF THE INVENTION:

Accordingly, it is a principal object of the  
present invention to provide a developing device in  
25 which the contamination by the reversely charged toner  
is effectively prevented.

It is another object of the present invention

to provide a developing device in which the deterioration of the image quality attributable to the reversely charged toner can be prevented.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS:

Figure 1 is a schematic illustration of a major part of an image formation processing portion of an image forming apparatus according to an embodiment of the present invention.

Figure 2 is a schematic view illustrating the behavior of the developer between the rotatable drum and the developer carrying member in a conventional image forming apparatus.

Figure 3 is a schematic view illustrating the behavior of the developer between the rotatable drum and the developer carrying member in a conventional image forming apparatus.

Figure 4 is a schematic view illustrating the behavior of the developer between the rotatable drum and the developer carrying member in a conventional image forming apparatus.



Figure 5 is a schematic view of a circuit of a developing bias generating device.

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A1 Figure 6 shows a waveform of a developing  
bias voltage.

5 Figure 7 shows a relation between the voltage upon stop of the waveform of the developing bias and the amount of the development toner transferred onto the drum.

10 Figure 8 show a sequence of operation in the conventional image forming apparatus.

15 Figure 9 is a schematic view illustrating the behavior of the developer between the rotatable drum and the developer carrying member in the image forming apparatus according to the embodiment of the present invention.

20 Figure 10 is a schematic view illustrating the behavior of the developer between the rotatable drum and the developer carrying member in the image forming apparatus according to the embodiment of the present invention.

25 Figure 11 is a schematic view illustrating the behavior of the developer between the rotatable drum and the developer carrying member in the image forming apparatus according to the embodiment of the present invention.

Figure 12 shows a relation between the voltage upon the stop of the waveform of the

developing bias and the amount of the toner transferred onto the drum in the image forming apparatus according to a first embodiment of the present invention.

5           Figure 13 shows a sequence of operation in the image forming apparatus according to the first embodiment of the present invention.

10           Figure 14 shows a waveform of a developing bias in an image forming apparatus according to a second embodiment of the present invention.

            Figure 15 shows a sequence of operation in the image forming apparatus according to the second embodiment of the present invention.

15           Figure 16 is a schematic illustration of a major part of an image formation processing portion of an image forming apparatus according to a third embodiment of the present invention.

20           Figure 17 is a schematic illustration of an image formation process portion of a conventional image forming apparatus.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS:

25           Referring to the accompanying drawings, the preferred embodiment of the present invention will be described. In the following descriptions, the dimensions, materials, configurations, relative position on relationships of elements constituting the apparatus of this invention are not limiting the

present invention, except for particular mentioning to the effect.

(First embodiment)

Referring to Figures 1 through 13, an image forming apparatus according to the first embodiment of the present invention will be described.

Referring mainly to Figure 1, the general arrangement of the image forming apparatus will be described mainly on the image forming process. Figure 1 is a schematic illustration of a major part of an image formation processing portion of an image forming apparatus according to the first embodiment of the present invention.

The electrophotographic photosensitive member (image bearing member) in the form of a drum is rotated in the direction indicated by an arrow X is uniformly charged by the primary charger 2, and the charging surface is exposed to image information light 3 which may be a laser beam modulated in accordance with image. By doing so, the potential of the illuminated portion attenuates, so that an electrostatic latent image is formed.

The electrostatic latent image reaches the developing zone where the developing sleeve 41 (developer carrying member) of the developing device 4 is opposed to the photosensitive drum 1. Then, the toner (developer) is deposited on the drum in

accordance with the electrostatic latent image, so that toner image is formed.

As this time, the developing sleeve 41 is supplied with an AC biased DC voltage (developing bias  
5 voltage). The rotational axis of the photosensitive drum 1 is parallel with the rotational axis of the developing sleeve 41, and a predetermined gap is maintained between the surfaces of them.

In this embodiment, the polarity of the  
10 charged photosensitive drum surface and a regular polarity of the toner are both negative, and the latent image is developed through a reverse development type. In this embodiment, the regular-charge toner is the toner charged to the regular  
15 charging polarity, and the reversely charged toner is the toner charged to the opposite polarity.

On the other hand, the sheet 6 (recording material) accommodated in a cassette 5 is fed out in synchronism with the toner image formation, and is fed  
20 by a feeding roller 7 and a pair of feeding rollers 8. The upper and lower surfaces of the sheet 6 is guided by guiding members which constitute a pair and which are opposed to each other (a upper guiding member 9 which is a first guiding member and a lower guiding member 10 which is a second guiding member). Thus,  
25 the sheet 6 reaches an image transfer station where a transfer charger 11 (transferring means) is supposed

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to the photosensitive drum 1.

By the rotation of the photosensitive drum 1, the toner image reaches the image transfer station.

At this time, the sheet 6 is closely contacted to the  
5 photosensitive drum 1. An image transfer bias voltage of the polarity (+) opposite to the toner toner is applied to the sheet 6 by the transfer charger 11, so that toner image is transferred onto the sheet 6.

Thereafter, the sheet 6 is fed to an image  
10 fixing means 12, where the unfixed toner image on the sheet 6 is fixed thereon by heat and pressure. The sheet 6 is then discharged to a discharging tray 14 by a pair of discharging rollers 13. On the other hand, residual toner remaining on the surface of the  
15 photosensitive drum 1 is removed by cleaning means 15 to be prepared for the next image forming operation.

The upper guiding member 9 and the lower  
guiding member 10 functions to assuredly guided the  
sheet 6 to the transfer station, so that sheet 6 is  
20 closely contacted into the surface of the photosensitive drum 1 during the image transfer operation.

For this purpose, the upper guiding member 9 and the lower guiding member 10 are disposed close to  
25 the surface of the photosensitive drum 1, and particularly, the distance between the free end portion 9s of the upper guiding member 9 and the

photosensitive drum 1 is 2.5mm where they are closest.

In this embodiment, the upper guiding member 9 and the lower guiding member 10 each comprise an electroconductive SUS metal plate 9a, 10a and an  
5 insulating member 9b, 10b of high density polyethylene resin material (insulative member), which are closely contacted to each other.

Surfaces of the insulating members 9b, 10b of the upper guiding member 9 and the lower guiding  
10 member 10 are contactable to the sheet 6, and during feeding of the sheet 6, they guided the top and bottom sides of the sheet 6.

The electroconductive metal plates 9a, 10a are supplied with a bias voltage having the same  
15 polarity as the toner (opposite from the polarity of the image transfer bias voltage) from a voltage source 16.

Referring to Figures 2-4, the description will be made as to the behavior of the toner between  
20 the photosensitive drum (rotatable drum) and the developing sleeve (developer carrying member) when the bias voltage application is stopped in the conventional image forming apparatus.

Figures 2-4 schematically illustrate the  
25 behavior of the developer (toner) between the rotatable drum and the developer carrying member in the conventional image forming apparatus.

Conventionally, the developing bias voltage application is stopped while keeping the rotation of the developing sleeve S (developer carrying member), and Figures 2-4 illustrate the behavior of the toner at the stop. Figure 8 shows a sequence of operation in the conventional image forming apparatus.

Figure 2 shows a state when the developing bias voltage has not been stopped; Figures 3 and 4 show the states immediately after the stop of the developing bias voltage, in which Figures 3 and 4 are different in the position on the waveform at which the developing bias voltage is stopped.

The photosensitive drum used is OPC photosensitive member having a diameter of 30 mm, and the surface thereof is uniformly charged by a primary charger to -720V. The developing bias voltage is an AC biased DC voltage in which the DC component  $V_{dc}$  is -560V, and the AC component is 800V, in the peak to peak  $V_{pp}$  and has a frequency of 1.8kHz. The developing sleeve used is a sleeve 20 which is rotated at a peripheral speed which is 1.8 times the peripheral speed of the drum. In this example, potential of the exposed portion (toner deposition portion) provided by the image exposure is -200.

The gap between the surface of the drum and the surface of the developing sleeve is 200 $\mu$ m. The reverse development of a jumping development type is

carried out using negative charged toner.

Although not shown, magnetic toner is applied into a thin layer coating (having a higher thickness of approx. 100 $\mu$ m) on the surface of the developing sleeve by functions of a magnetic blade and a magnetic confining force provided by a stationary magnet disposed in the sleeve at a position opposed to the magnetic blade. By the rotation of the developing sleeve, the magnetic toner is carried to the effective developing zone.

The effective developing zone means a zone in which the distance between the surface of the photosensitive drum and the surface of the developing sleeve is so small that toner carried on the developing sleeve is able to transfer to the surface of the photosensitive drum.

When the image formation (development) operation is stopped, the primary charger is kept actuated in the duration in which the AC bias voltage is applied to the developing sleeve (until the developing sleeve potential becomes 0) after the start of the rotation of the developing sleeve (although the image exposure is not performed), such that portion of the surface of the photosensitive drum which is going to pass through the developing station is electrically charged. By doing so, the regular-charge toner is not deposited on the photosensitive drum even



if the toner oscillates.

Figure 2 shows the state before the developing bias voltage application is stopped, as described hereinbefore. Both of the photosensitive drum and the developing sleeve S are rotated with the developing bias applied.

In this Figure, the toner particles having the negative charge which is the regular charging are indicated by "o", and the so-called reversely charged toner having the positive charge which is the opposite is indicated by "o" with hatching lines.

In the effective developing zone, the toner reciprocations following the changes of the electric field between the drum and the developing sleeve and a frequency equivalent to 1800Hz. After the development, the toner is transferred onto the drum corresponding to the contrast potential which is a difference between  $V_{dc}$  and the light portion potential.

Thus, when the photosensitive drum and the developing sleeve are located, and the developing bias voltage is applied, a small amount of reversely charged toner is transferred onto the photosensitive drum. Other than that, no toner transfer onto the photosensitive drum which may cause the deterioration of image quality is not observed.

Figures 3 and 4 to show the states

immediately after the start of the developing bias voltage application, more particularly, the transient states which case the developing bias voltage application is stopped, while the photosensitive drum and the developing sleeve S are kept rotated.

Here, referring to Figure 5, a developing bias generating device will be described. As shown in this Figure, the developing bias voltage is provided by amplifying an input signal of 1800Hz by a step-up transformer and is superimposed with a DC voltage Vdc. The trace of the waveform upon the stop of the developing bias voltage application is determined by the state of the time of stop of the input pulse signal and the direction of widening of the step-up transformer. Depending on the timing of the stop signal, there are inevitably two types of traces of waveform.

The two types of waveforms are shown in Figure 6, in which (A) deals with the case in which the bias waveforms at the developing position stops at Vppmax, and (B) deals with the case in which the bias voltage waveform stops at Vppmin.

Figure 3 illustrates a behavior of the toner adjacent the effective developing zone when the developing bias stops with the waveform shown in Figure 6 (A).

As shown in (A) in Figure 6, when the input

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signal ends at the Low, the developing bias voltage level attenuates from  $V_{ppmax}$  (-160V) to the developing bias  $V_{dc}$  (A region), and the voltage is temporarily maintained at  $V_{dc}$  (B region), and then further  
5 attenuates to 0V since the drum charging operation and  $V_{dc}$  stops (C region).

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In this case, before the developing bias voltage application is stopped, the toner oscillates or reciprocate between the photosensitive drum and the  
10 developing sleeve S in a floating state, in the effective developing zone, as has been described in conjunction with Figure 2.

When the bias voltage waveform application stops at  $V_{ppmax}$  (-160V), a strong back-transfer  
15 electric field (electric field applying the holes to the regular charge toner in the direction of moving toward the developing sleeve) between the photosensitive drum and the developing sleeve, and therefore, only the reversely charged toner in the  
20 floating toner is selectively transferred onto the drum with the result of fog in the form of a stripe.

Since the developing sleeve S continues to rotate even in the B region, the reversely charged toner is always supplied, and therefore, the reversely  
25 charged toner continues to be deposited onto the photosensitive drum (Figure 3).

Therefore, as described in the foregoing, the

reversely charged toner is attracted by the buyers voltage applied to the free end portion of the transfer guide, with the result of contamination at the leading and trailing edges of the sheet.

5           This phenomenon is not very remarkable in normal cases, and therefore, quite a long time is required for the contaminating toner to accumulate, and the contamination of the sheet occurs at interval, not continuously. However, under an extreme low  
10 humidity ambient condition, if the developing operation is repeated for a long term, the toner becomes excessively charged. The excessively charged toner is firmly deposited on the surface of the developing sleeve, so that toner particles are not  
15 exchanged. Then, the proper electric charge application to the toner is obstructed. The amount of electric charge of the toner decreases, and the amount of the reversely charged toner increases. In the worst case, the contamination occurs continuously.

20           In the C region the charged potential of the drum and the developing bias  $V_{dc}$  are the same levels and attenuate to 0V, and therefore, the toner is hardly deposited on the drum.

Sub B8 25           Figure 4 illustrates a behavior of the toner adjacent the effective developing zone when the developing bias stops with the waveform shown in Figure 6 (B).

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As shown in (B) in Figure 6, when the input signal ends at the High, the developing bias voltage level attenuates from  $V_{ppmin}$  (-960V) to the developing bias  $V_{dc}$  (A region), and the voltage is temporarily maintained at  $V_{dc}$  (B region), and then further attenuates to 0V since the drum charging operation and  $V_{dc}$  stops (C region).

In this case, before the developing bias voltage application is stopped, the toner oscillates or reciprocate between the photosensitive drum and the developing sleeve S in a floating state, in the effective developing zone, as has been described in conjunction with Figure 2.

When the bias voltage waveform stops at the  $V_{ppmax}$  (-960V), the developing electric field (the electric field applying to the toner particles the force in the direction moving the toner having the regular charge to the photosensitive drum) between the photosensitive drum and the developing sleeve.

Therefore, the regular-charge toner floating and oscillating in the developing zone, that is, most of the toner particles are transferred onto the photosensitive drum with the result of a stripe which is similar to halftone image.

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In the B region, the situation is the same as with Figure 6, (A) and Figure 3. Since the developing sleeve continues to rotate, the reversely charged

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toner in the toner supplied for development is always  
supplied, and therefore, the reversely charged toner  
~~is continuously supplied to the drum.~~

Thus, the free end portion of the transfer  
5 guide is contaminated by the small amount of the  
reversely charged toner with the result of  
contamination of the image, although it is not so  
remarkable as in the foregoing case.

Even if the developing operation is repeated  
10 under an extreme low humidity ambient condition for a  
long term, quite a long time is required for the  
contaminating toner to accumulate, and the  
contamination of the sheet occurs at interval, not  
continuously, since the electric field force for  
15 transferring the reversely charged toner to the drum  
upon the stock of the bias voltage waveform is not as  
large as with the foregoing case.

However, the stripe of the regular-charge  
toner formed on the drum causes contamination of the  
20 elements dispose close to the drum due to the airflow  
caused by the job location. When the regular-charge  
toner constituting the stripe is collected by the  
cleaner, the toner may fall from a toner receptor  
sheet.

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In the C region, charged potential of the  
drum and the developing bias  $V_{dc}$  are that same levels  
and attenuate to 0V, and the toner is hardly transfer

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onto the photosensitive drum.

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Figure 7 shows the results. In this Figure, the abscissa represents the voltage upon the stop on the developing bias, and the ordinate represents the amount of development of the right formed on the drum.

In the figure, the left side deals with the data in the case of Figure 3, and the right side deals with the data in the case of Figure 4. As will be understood, the case of Figure 3 involves the more significant problem, since the contamination can be continuous.

In Figure 7, the data of -700V in the middle is an ideal bias voltage waveform when the amplifier is connected with a pulse generator capable of forming any waveform at the start to provide the same potential as the drum potential upon the stop of the waveform (the toner transfer is least). The problems can be avoided even when the toner is quite deteriorated under the extremely low humidity ambient condition.

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However, even with such a waveform, the toner is oscillating immediately after the application of the bias waveform, and therefore, there is no urging force provided by the photosensitive drum or the developing sleeve. For this reason, the low charging toner floating in the developing zone is deposited on the transfer guide and so on due to the air flow or

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simple (non-electrical) scattering. This may be a factor of contaminating the sheet.

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In addition, such a bias voltage waveform is not practical for the commercial machines, since the  
5 required equipment is too expensive.

The description will be made as to the behavior of the toner in the embodiment of the present invention.

The inventors have found an interesting  
10 phenomenon. This is shown in Figure 9.

That is, while keeping the rotation of the photosensitive drum, the rotation of the developing sleeve S is stopped, and the developing bias is applied. The toner in the effective developing zone  
15 repeats the reciprocating motion, and the toner is shifted to outside the effective developing zone and forms banks at the edges of the effective developing zone.

The reason is considered as follows. The  
20 surface of the photosensitive drum and the surface of the developing sleeve are not flat but is curved. Therefore, the gap is not uniform, and gradually increases away from the center of the effective developing zone. Because of this, the toner particles  
25 which repeats elastic collision gradually shift to larger gap portions. Since the reverse development type is used, the surface potential of the



photosensitive drum is maintained at -720V, and the Vdc component of the developing sleeve is set to -560V, the regular-charge toner particles reciprocally moves, but the electric field force is oriented toward  
5 the developing sleeve side, and therefore, the surface of the drum is not developed.

For example, if the toner particles are responsive to 1.8kHz, which means that one cyclic period is 0.55msec, and therefore, 100 reciprocations  
10 are possible. The bias voltage application time duration of not less than approx. 50msec is enough to shift the toner to the outside of the effective developing zone.

In addition, the following has been found.  
15 This phenomenon is particularly remarkable with respect to the toner particles sufficiently charged to the regular polarity, and such toner shifts to the outside of the effective developing zone, since only such toner particles are responsive to the alternating  
20 electric field. Because of this, only the reversely charged toner and the toner having low level regular charge remain in the effective developing zone.

If the amount of electric charge its small, the force applied thereto by the function of the  
25 electric field is also a small, and therefore, such toner is unable to respond the alternate oscillation at the frequency of 1.8kHz. Normally, not all the

surface of the reversely charged toner has the positive charge, but there are a positive polarity portion and a negative polarity portion as a result of polarization, and macroscopically, the polarity is positive. For this reason, the amount of electric charge cannot be increased by the charge control material or externally added material having a strong power of charging the toner to the negative polarity.

The measured amount of electric charge of the toner remaining on the effective developing zone was -10 mC /kg normally, but the amount measured after the application of the developing bias after the stop of the developing sleeve S was -1.5 mC /kg (never positive) which is relatively small. The amount of electric charge of the toner in the banks outside the effective developing zone was -12 mC /kg which is relatively large. This supports the above-described consideration.

Sub B12 20 The investigation has been made as to the behavior of the toner with the use of the developing bias waveform shown in Figure 6, (A) and (B).

Figure 10 illustrates a behavior of the toner adjacent the effective developing zone when the developing bias stops with the waveform shown in Figure 6, (A).

As shown in (B) in Figure 6, when the input signal ends at the Low, the developing bias voltage

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level attenuates from  $V_{ppmax}$  (-160V) to the developing bias  $V_{dc}$  (A region), and the voltage is temporarily maintained at  $V_{dc}$  (B region), and then further attenuates to 0V since the drum charging operation and  $V_{dc}$  stops (C region).

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In this case, before the developing bias voltage application stops, the toner is oscillating or reciprocating between the photosensitive drum and the developing sleeve S in a floating state by the AC in the effective developing zone, similarly to the case of Figure 9.

When the bias voltage waveform application stops at  $V_{ppmax}$  (-160V), a strong back-transfer electric field (electric field applying the holes to the regular charge toner in the direction of moving toward the developing sleeve) between the photosensitive drum and the developing sleeve, and therefore, only the reversely charged toner in the floating toner is selectively transferred onto the drum with the result of fog in the form of a stripe.

However, in this embodiment, is the developing sleeve S is not rotated, the amount of the transferring toner is one half the amount in the case of Figure 3. In the B region, since the developing sleeve is not rotated, there is no toner supplied, and therefore, the reversely charged toner is not deposited onto the photosensitive drum.

Therefore, until the light stripes formed by the reversely charged toner produced upon the stop of the developing bias waveform application is accumulated, an even longer time is required, and the frequency of the contamination of the sheet is quite low.

However, the reversely charged toner is attracted to the free end portion of the transfer guide by the bias voltage applied to the transfer guide, so that reversely charged toner is deposited there with the result of contamination of the leading and trailing edges of the sheet.

However, even if a large amount of the toner is produced in a long term operation under the extreme low humidity ambient condition, the frequency of the sheet contamination is one half as compared with the conventional developing device.

Figure 11 illustrates a behavior of the toner adjacent the effective developing zone when the developing bias stops with the waveform shown in Figure 6, (B).

As shown in (B) of this Figure, when the input signal ends at the High, the developing bias voltage level attenuates from  $V_{ppmin}$  (-960V) to the developing bias  $V_{dc}$  (A region), and the voltage is temporarily maintained at  $V_{dc}$  (B region), and then further attenuates to 0V since the drum charging

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operation and  $V_{dc}$  stops (C region).

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In this case, before the developing bias voltage application is stopped, the toner oscillates or reciprocate between the photosensitive drum and the developing sleeve S in a floating state, in the effective developing zone, as has been described in conjunction with Figure 9.

When the bias voltage waveform stops at the  $V_{ppmax}$  (-960V), the developing electric field (the electric field applying to the toner particles the force in the direction moving the toner having the regular charge to the photosensitive drum) between the photosensitive drum and the developing sleeve.

In this embodiment, since the toner having the regular charge is outside the effective developing zone as described hereinbefore, there is hardly any toner that has the regular charge, in the floating toner.

Therefore, even if the developing electric field exists, the toner does not transfer onto the photosensitive drum.

In addition, the floating reversely charged toner receives the force toward the surface of the developing sleeve by the developing electric field, and therefore, the toner is (closely) contacted to the surface of the developing sleeve.

In the next B region, the mirror force

between the reversely charged toner and the developing sleeve is proportional to the distance squared, and therefore, the mirror force is larger than the electric field force even if the amount of electric charge is small. Thus, the amount of the reversely charged toner deposited on the photosensitive drum is very small.

Figure 12 shows the results. In this Figure, the abscissa represents the voltage upon the stop of the waveform stop of the developing bias, and the ordinate represents the amount of development of the stripe formed on the drum.

The left side deals with the data described in conjunction with Figure 10, and the righthand side deals with the data described in conjunction with Figure 11. As compared with Figure 5 of the prior art example, the contamination is reduced to one half with the waveform (A) of Figure 6, and the contamination is quite reduced with the waveform (B) of Figure 6.

The developing device according to this invention was incorporated in an actual machine, and the durability test was carried out with very low print ratio under the extreme low humidity ambient condition (23°C, 5%). The number of contaminating sheets and the contamination level of the transfer guide were checked after 100,000 sheets are intermittently processed. Table 1 shows the results.

CONTAMINATIONS

	-----		
	Voltage		
	at	-160V	-960V
5	stop		
	-----		
	Bias stop		
	during sleeve	15 sheets *1	12 sheets *2
	rotation/	N	F
10	New app.		
	-----		
	Bias stop		
	during sleeve	>200 *1	23 sheets *1 *2
	rotation/	X	N
15	100,000		
	-----		
	Bias stop		
	during rest	0 sheet	0 sheet
	of sleeve/	F	E
20	New app.		
	-----		
	Bias stop		
	during rest	10 sheets *1	0 sheet
	of sleeve/	N	G
25	100,000		
	-----		

In this Table, "E" indicates that no toner deposition is observed at the free end portions of the upper and lower guides: "G" indicates that small amount of toner is observed at the free end portions of the guides, but there will not arise any problem even if the tests continues further: "F" indicates that certain amount of toner is observed at the free end portions of the guides, but no contamination of the sheet occurred; nevertheless, the contamination of the sheet will occur in the test continues further: "N" indicates that toner deposition is observed at the entirety of the free end portions of the upper and lower guides to such an extent that toner is accumulated into a bulge. "X" indicates that situation is worst such that contamination continues from the free end portions of the upper and lower guides to positions away from the photosensitive drum. The contamination of the guides and the contamination at the leading and trailing edges are interrelated. in the The Table, \*1 means contamination at the leading and trailing edges of the sheet; and \*2 means toner falling from receptor sheet.

From the results of the tests, it is understood that in the conventional example in which the developing bias voltage is stopped while keeping the developing sleeve rotated, the contamination of the guide is observed irrespective of the voltage at



the time when the bias waveform is stopped, and the sheets are contaminated although the number of sheets are different.

5 On the other hand, by stopping the developing bias office application of other stopped of the developing sleeve rotation, the effects are different. In the case that is stopped at -160V, the effects are recognized to a certain degree, but not complete against the contamination. With the increase of the number of operations, the amount of the reversely charged with toner increased, the sheet contamination occurs.

10 On the contrary in the case of stop a -960V, the sheet contamination or the transfer guide contamination does not occur even in the long term operation which necessarily results in increase of the reversely charged toner. The effects are very remarkable. A substantially complete interrelation with the amount of the toner on the photosensitive drum. Figures 13 shows a sequence of operations of the drum driving, the drum charging, the developing sleeve driving and bias voltage application to the developing sleeve.

15 As described in the foregoing, according to this embodiment, the developing sleeve is stopped during the rotation of the photosensitive drum, and the bias voltage is kept applied for a certain period,

and thereafter, the bias voltage waveform application is stopped while the developing electric field is formed. By this, the toner having the sufficient regular charge can be expelled from the effective  
5 developing zone, and the reversely charged toner is urged to the surface of the sleeve by the force produced by the developing electric field, so that mirror force between the toner and a surface of the developing sleeve is increased to prevent the position  
10 of the toner onto the photosensitive drum.

In the foregoing embodiments, the description has been made as to the reverse development type, but the present invention is applicable to the regular developing system.

15 However, the advantageous effects of the embodiments are remarkable in the case of the reverse development type, since the polarity of the surface potential of the photosensitive drum is the same as the polarity of the toner, and therefore, the  
20 electrical mirror force is small with the result of worse contamination of the transfer guide or like.

(Second embodiment)

Figures 14 and 15 shows the apparatus according to the second embodiment of the present  
25 invention.

This embodiment is different from the first embodiment only in the stop timing of the DC bias, and

the fundamental structures are the same as with the first embodiment, and therefore, the description of the common parts are omitted for simplicity.

Sub B14  
5 In the first embodiment, the stop timing of the developing bias, particularly the AC bias is the feature. In this embodiment, the stop timings of the DCmin. And the ACmin. Of the developing bias voltage.

10 Although the detailed description is omitted in the first embodiment, the DC component is stopped after stop of the AC component as shown in Figure 13. When the photosensitive drum and the developing sleeve are rotated in synchronism with each other, the surface potential of the photosensitive member becomes  
15 OV upon stop of the charging of the photosensitive drum, and AC component should be removed, since otherwise the photosensitive drum is developed to a solid black with a very large amount of the toner because the developing power is very strong under the  
20 DC component alone, and the developing sleeve is rotated to supply always the toner into the developing zone. The toner is scattered to the parts around the photosensitive drum. The above-described sequence is the known as common means in the conventional  
25 electrophotographic type normal.

However, the problem has been solved by applying the developing bias with the developing

sleeve at rest. This is because the toner having the having t sufficient regular charge can be expelled from the effective developing zone, as has been described in the description of the first embodiment.

5 By doing so, the DCmin. And the ACmin. Of  
the developing bias can be simultaneously stopped, so  
that transfer guide contamination or the like by the  
small amount of reversely charged toner produced  
during the period in which only the Vdc is applied,  
10 and the leading and trailing edge contamination of the  
sheet can be avoided.

Referring to Figure 14, the description will  
be made in detail. Figure 14 is a waveform graph of a  
developing bias in an image forming apparatus (in a  
15 transient state upon the bias voltage waveform stop).

As shown in this Figure, when the input  
signal ends at the High, the developing bias voltage  
level attenuates from Vppmin (-960V) to the developing  
bias Vdc (A region), and then, without maintaining the  
20 voltage at Vdc, the voltage attenuates to 0V since the  
drum charging operation and Vdc stops (C region).

In this case, before the developing bias  
voltage application is stopped, the toner oscillates  
or reciprocate between the photosensitive drum and the  
25 developing sleeve S in a floating state, in the  
effective developing zone, as has been described in  
conjunction with Figure 9.

When the bias voltage waveform stops at Vppmax (-960V), the developing electric field is formed between the photosensitive drum and the developing sleeve.

5 Here, in this embodiment, similarly to the first embodiment, there is hardly any toner that has the regular charge, in the floating toner, and therefore, no toner is transferred onto the photosensitive drum. In addition, the reversely  
10 charged toner floating in the developing electric field is (closely) contacted.

In this embodiment, there is no B region unlike the first embodiment, no reversely charged toner is deposited onto the drum.

15 The amount of the development of the reversely charged toner transferred onto the photosensitive drum upon the waveform stop, was unmeasurably small both in the case of a new a developing apparatus and the developing apparatus  
20 operated for 100,000 sheet durability test.

Then, investigations have been made by 100,000 sheet durability test, using an axial machine under the extreme low humidity ambient condition (23°C, 5%). The 100,000 sheets were processed,  
25 because 10,000 sheet test is not sufficient to check the effects. Table 2 shows the results.

CONTAMINATIONS

	Developing	After DC off	Simultaneous
	Bias	DC off	AC and DC
5	Sequence		stop
	Guide	11 sheets	0 sheet
	Contamination	F	G

10 From the tests, it is understood that even when the developing sleeve is stopped during the rotation of the drum, and the developing bias is applied for a certain period of time, and thereafter, both of the DC and AC components are stopped, no sheet

15 contamination more transfer guide contamination occurs even using the developing device after the durability tests (100,000 sheet).

20 Figure 15 shows a sick ratio operations for the drum driving, the drum charging, the developing sleeve driving and the developing sleeve bias application.

25 In this manner, when the developing sleeve is stopped during the rotation of the drum, and the developing bias is applied for a certain period of time, and thereafter, both of the DC and AC components are stopped, the toner having the sufficient regular charge can be expelled from the effective developing

zone, and the reversely charged toner is urged to the sleeve surface by the force provide by the developing electric field, so that in the mirror force is increased to prevent scattering to the photosensitive drum.

(Third embodiment)

Figure 16 shows apparatus according to a third embodiment of the present invention.

In this embodiment, the transferring means is a non- contact type transfer charger which is not directly contacted to the sheet, but the present invention is applicable to the case using a contact type transferring means. The fundamental structures are the same as in the following embodiments in other respects, and therefore, the detailed description is omitted for simplicity.

Figure 16 is a schematic illustration of a major part of an image formation processing portion of an image forming apparatus according to the first embodiment of the present invention.

As shown in this Figure, this embodiment uses a contact transfer type, that is, the transferring means is a transfer roller 17.

Generally, when the use is made with the transfer roller, the transfer roller is always in contact with the photosensitive drum. There arises no problem in the period in which the sheet is passing

through the transfer station. However, during a pre-rotation, doing a post-rotation and between adjacent sheets, the toner deposited on the photosensitive drum by the developing action may contaminate the transfer roller by physical and electrical forces. The toner may accumulate and contaminate the backside of the sheet.

It is known that in a system using the transfer roller, the transfer roller is supplied with an opposite polarity bias voltage (opposite from the polarity of the transfer bias) to clean the transfer roller during the pre-rotation, a sheet interval or post-rotation. By doing so, the toner accumulated on the roller by the electric field force can be transferred onto the photosensitive drum.

However, as for the reversely charged toner upon the deactuation of the developing bias voltage application, the amount of electric charge thereof is small irrespective of the polarities, and therefore, they are not easily influenced by the electric field force. For this reason, the above-described cleaning mode operation does not work.

Thus, the best means to avoid the contamination is to prevent the reversely charged toner from transferring onto the drum. It has been confirmed that by using the stop timing for the developing bias according to the first or second



embodiment to prevent the reversely charged toner from transferring onto the photosensitive drum, the contamination can be avoided in the case where the transferring means is a transfer roller.

5                    With respect to the apparatus of this embodiment, the tests similar to the first embodiments were carried out. Table 3 shows the results.

CONTAMINATION

10	Voltage	-160	-960
	at stop		
15	Bias stop		
	During	155 sheets	42 sheets
	sleeve rotation		
20	Bias stop		
	After sleeve stop	12 sheets	0 sheet

As will be understood from this table, when the developing bias is stopped after the stop of the developing sleeve, the number of sheets having the backside contamination is smaller than with the case in which the developing bias voltage application is

sub  
B22  
25

B2-2  
contd. [stopped during the rotation of the developing sleeve.

By stopping the developing bias voltage application while the developing electric field (-960V), the number of sheets having the backside contamination was zero in 100,000.

As described in the foregoing, according to this embodiment, the developing sleeve is stopped during the rotation of the photosensitive drum, and the bias voltage is kept applied for a certain period, and thereafter, the bias voltage waveform application is stopped while the developing electric field is formed. By this, the toner having the sufficient regular charge can be expelled from the effective developing zone, and the reversely charged toner is urged to the surface of the sleeve by the force produced by the developing electric field, so that mirror force between the toner and a surface of the developing sleeve is increased to prevent the position of the toner onto the photosensitive drum. In addition the transfer roller contamination can be avoided.

Sub B23  
Similarly, by simultaneous stop of the AC bias component and the DC bias component of the developing bias voltage while the developing electric field is formed, the advantageous effects are further enhanced.

As described in the foregoing, when the

developing bias is stopped, the developer having the regular charge is shifted to outside of the effective developing zone by the AC bias, and the AC bias is stopped in the state in which the regular-charge toner is being attracted to the image bearing member, and therefore, the reversely charged toner charged to the polarity opposite from that of the regular toner can be attracted to the toner carrying member. Therefore, the deterioration of the image quality attributable to the toner which is not to contribute to the information.

While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modification or changes or changes as may come within the purposes of the improvements or the scope of the following claims.